AUTO-TRACTION DYNAMOMETER FOR AUTOMOBILE CHASSIS

BY

W. H. GOETZ
A. N. KOCH
L. C. MEYER

ARMOUR INSTITUTE OF TECHNOLOGY

1914

DESIGN *and* CONSTRUCTION OF AN AUTO-TRACTION DYNAMOMETER FOR AUTOMOBILE CHASSIS

A THESIS

PRESENTED BY

WILLIAM HENRY GOETZ
ALBERT NICHOLAS KOCH
LESLIE CARL MEYER

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

MECHANICAL ENGINEERING

MAY 28, 1914

G. F. Gebhardt
L. C. Monin
H. M. Raymond

THE OBJECT.

The object of this thesis is the design and construction of an auto-traction dynamometer for testing automobile chassis.

PREFACE

The primary object of this thesis was to design and construct an auto-traction dynamometer in connection with a horse power meter, to be used in the testing of automobiles. This horse power meter was so designed as to be able to measure the horse power delivered to the rear wheels direct. Thus, knowing the horse power of the engine, the loss in the various parts of the transmission are evidenced. Time did not permit of the entire construction of the horse power meter, hence the actual testing must be left to a member of next year's class.

The thesis is divided into three parts.

First: The Description of the Apparatus.

Second: The Design and Construction.

Third: A Test with the Aforesaid Apparatus.

In Part 1 is given the description of the automobile, the dynamometer and the general layout of the apparatus.

Part 2 contains the actual design and construction of the dynamometer and its appurtanances

including the horse power meter.

In Part 3 is given the results of the tests obtained.

W. H. G.

A. N. K.

L. C. M.

TABLE OF CONTENTS.

Table of Contents. Page.

Part 3.

A Test.

Appendix.

LIST OF ILLUSTRATIONS.

Part One.

Description of the automobile used, the dynamometer and the general layout of the apparatus.

The Halladay Chassis.

The automobile chassis used in connection with the auto-traction dynamometer was a 1911 Model Halladay "40" made by the Halladay Motor Co., of Streator, Illinois. It is an assembled chassis, the engine, transmission, etc., being furnished by different concerns. The chassis is at the present time three years old, but it still has many features of the cars of its class today.

The engine used in this chassis is the well known Rutenber motor, made by the Rutenber Motor Co., of Marion, Indiana. The engine, known as the type R. A. Rutenber, is of the four cylinder water cooled type, $4\frac{1}{2}$" bore and 5" stroke, and is rated by its makers as a 35 - 40 Horsepower motor. The Society of Automobile Engineers' rating of this motor is 32.4 Horsepower at a piston speed of 1000 feet per minute. It is an L-head motor and the cylinders are cast separately, each one being bolted to the crank case. Cooling is effected by means of a large honey-comb type of radiator, the circulation being produced by a brass

gear pump on the motor. The gear pump is driven directly from the forward end of the cam shaft.

The clutch used on the Halladay is of the multiple disc type, the discs running in a bath of oil. The fly-wheel of the motor is a part of the clutch. The clutch is fitted with a small surface brake so that when the clutch is thrown out the brake is applied, but not hard enough to hinder the shifting of the gears. A short shaft extends from the clutch to the transmission which is located amidships.

The selective type of transmission is used in this chassis. This was made by the A. O. Smith Co., of Milwaukee, Wisconsin, who also furnished the front and rear axles. The transmission is of the usual three speeds forward and one reverse type. The following are the gear ratios:

1st or Low gear	11.45 to 1
2d or Second gear	5.83 to 1
3d or High gear	3.50 to 1
Reverse	13.33 to 1

Direct drive is on third, that is, the bevel gears on

the rear axle and propeller shaft are in the ratio of 3½ to 1. The propeller shaft which connects the rear axle and the transmission is enclosed in a torque tube. One universal joint is used and this is placed just outside of the transmission case housing. This universal joint is fitted with a leather covering so that no dirt can work in around it. The entire propeller shaft is enclosed for the same reason.

The rear axle is a full floating one, that is, none of the weight of the car is held by the line shafts in the rear axle. The housing of the shafts carries the weight of the car. The rear wheels rotate on two ball bearings which are placed at the ends of the axle housing. This is without a doubt the best type of axle made and the Halladay was an early car to use this type of construction.

The wheel base of this chassis is 118 inches and the tread standard, (56 inches). The wheels are wooden, of the artillery type and are fitted with quick detachable rims. At the time of writing, the Halladay chassis was fitted with 36" by 3½" Miller tires and tubes, plain tread casings on the front, and non-

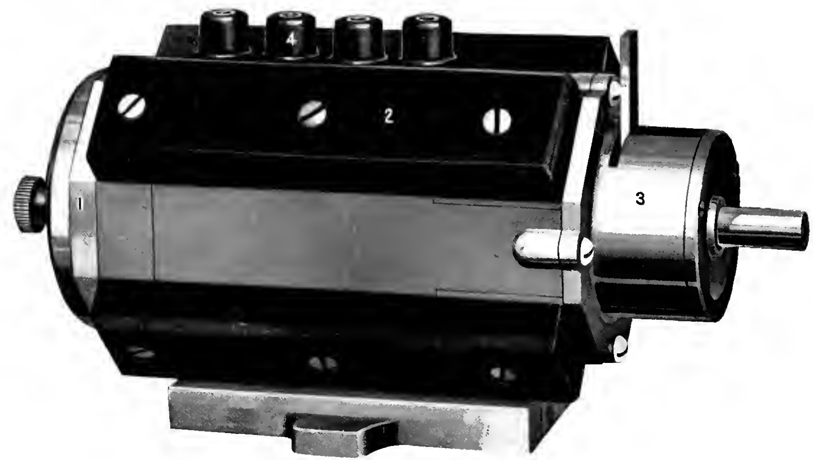
skid tread casings on the rear wheels.

The front axle is a pressed steel tubular one approximately square in cross-section. The chassis is equipped with the Gemmer worm and sector type of steering system. It is a reversible steering gear. The wheel used is 18 inches in diameter. The spark and gasoline control levers are located on the steering column just above the wheel. The chassis was not equipped with a foot throttle although one could be connected up very easily.

At the present time a double ignition system is used on the Halladay chassis. Each cylinder of the motor is fitted with two spark plugs, one for battery ignition and one for ignition by the magneto. Battery ignition is furnished by a six volt Exide Storage Battery using a four unit spark coil; that is, each cylinder has its own coil and vibrator. The coils used were made by the Pfanstiehl Electric Laboratory of North Chicago, Illinois. The battery ignition is timed by a timer located on the engine. The magneto used is of the high tension type known as the Hibbard magneto and made by the Grip Nut Co., of Chicago, Illinois.

This magneto is a four pole machine and is operated at cam shaft speed. It fires serially as shown by the numbers which are placed upon it. The connections of the magneto are made directly to the cylinders, no timer or separate distributor being used or needed because the timing is taken care of in the magneto itself. This magneto differs from most magnetos in that it is a four pole machine, most magnetos having but two poles. The advantages of having a double ignition system such as this are that we have two independent systems which can be used; if one is put out of commission entirely the other is not affected. However, the double system has the disadvantage that eight spark plugs are needed in place of four, thus requiring greater attention. In running the Halladay, the motor was generally started with the battery ignition and then thrown on the magneto. When the motor was warm, or had a charge of gas in the cylinders it could be started on a quarter turn with the magneto, showing a very strong spark from this type.

When work was started on this thesis, the Halladay chassis was not equipped with the Hibbard mag-



The Hibbard Magneto measures 10 1-2 inches in length over all, 4 inches in width and 5 inches in height. Part marked No. 1 is the removable front cap containing the condenser, No. 2 are the magnets, No. 3 is the removable rear cap containing the differential gear, and No. 4 are the high tension cable connections.

FIG. 1.

neto and the timer of the motor was not connected for battery ignition. The firing order of the motor was determined and the timer connected for the correct firing order. After the battery ignition was connected up, the magneto was fitted to the motor and connected up for the correct firing order, the same as the battery. The magneto was connected to a switch on the dash board so that the engine could be stopped by short circuiting the magneto, also so that the motor could be started on the battery ignition and changed to the magneto.

The seat on the chassis was remodelled so that a gasoline tank could be placed beneath it and held by it. The frame of the seat was made of $\frac{1}{2}$" by 2" steel and bolted to the frame of the chassis. The gasoline tank is held by a cross-member of the seat frame.

Connection was made to the carburetor by the standard brass tubing. The carburetor used in this chassis was a Schebler model D $1\frac{1}{4}$" size. This carburetor is rather hard to start on but seemed to give good results at moderate speeds. The closing

of the air valve gave trouble at times.

A floor was made to cover up the front part of the chassis and to help the driver in the operation of the clutch and foot brake. The floor was made so that it could be easily removed and access had to the clutch and transmission.

The chassis was fitted with a 1913 model E-1 Stewart speedometer, including besides the speedometer, a grade indicator and clock.

The Dynamometer.

The power delivered to the rear wheels by the engine was absorbed by an Alden Dynamometer (Fig. 2). This type was chosen because of its compactness and the ease with which it may be adjusted to suit varying conditions.

The dynamometer consists of a cast iron disc (B) keyed to a two inch shaft. This shaft supports the pulleys on which the rear wheels of the automobile rest. The disc rotates between two stationary copper diaphragms (D). The disc and diaphragms are inclosed in a cast iron casing (A) which is free to rotate about the shaft. Cap bolts hold the dynamometer together. To make possible a water tight joint between the diaphragms and the casing at the shaft, a wedge ring is used. Space between the disc and diaphragms is held by means of the ring (C). The space may be increased or decreased by the inserting or removing of paper gaskets.

The power delivered by the rear wheels is absorbed by the friction between the copper diaphragms

and the cast iron disc. This friction is brought about by means of water pressure on the copper discs. By a regulation of the water pressure, any desired load may be obtained. To measure this power, an arm is attached to the outer casing and rests upon a strut on a small platform scale. The length of the arm is 18.925 inches

The water spoken of above, enters the dynamometer at (J) and distributes itself equally in the annular spaces (H). It then passes through these and leaves at (K). By a regulation of either the inlet or discharge valves, any desired pressure may be obtained.

Oil is fed between the disc and the diaphragm either through an orifice in the middle ring or through two oil cups which feed the brass bearings. The brass bearings are shown at (N).

General Layout.

The arrangement of the apparatus is as follows: Two pulleys (A) Fig. 3, revolve on a shaft (C) which is held in place by four cast iron brackets (B). These brackets are mounted on a cast iron base (D), which is set approximately four and one half feet below the floor level. At the center of the shaft is situated the dynamometer. The rear wheels (W) of the automobile rest upon the pulley faces. The machine is held from going forward by a cable (E) in which is inserted a dial scale to measure the traction effort. Brackets hold the machine from swaying to either side. The machine was started and the gears placed in direct drive. The load on the dynamometer was recorded as well as the revolutions per minute of the pulleys, which was obtained by a tachometer (T). The horse power absorbed was then calculated. The tractive effort was also calculated, knowing the load recorded on the dial spring scale.

The horse power meter, which was not completed was to read the horsepower of the rear wheels direct. The design and construction will be discussed later.

Part 2.

Design and construction of the Dynamometer with its appurtanances including the Horse Power Meter.

The Dynamometer Test Rack.

To find the power transmitted by the rear wheels, some method of absorbing that power is necessary. For that reason the test rack, shown in Fig. 1, was designed and constructed. The particular design was chosen because of its strength, compactness and accessability. The parts are of cast iron with the exception of the shaft, which is of nickel chrome steel, and were made at the Armour Institute of Technology. We shall discuss the bed plate, pedestals, shaft and pulleys in the following paragraphs.

The bed plate upon which the pedestals, that act as bearings for the shaft rest, is rectangular, six feet eleven inches long, two feet five inches wide and five inches high. The bed plate is hollow with the exception of half inch ribs, one running lengthwise in the center, and two running crosswise, spaced two feet three and a half inches from the ends. On the top face of the plate are four planed surfaces, seven inches wide and twenty-four inches long. The pedestals rest upon these surfaces and are held in place by four $\frac{3}{4}$" cap screws. The details of the plate are given in Fig. 4.

The pedestals are shown in Fig. 5. They are of cast iron, 24" X 6" on the base, and 2' 0" high, the latter dimension being measured from the base to the center line of the bearing. The bearings are of the roller bearing type, with an outside diameter of three and one half inches and an inside diameter of one and fifteen sixteenths inches. The bearing is placed in a recess in the top of the pedestal and held in place by means of a special cap shown in detail in Fig. 6. Three, three eighths inch cap screws placed one hundred and twenty degrees apart, hold the cap and bearing in place. The pedestals have a plane base, thus permitting of a rigid connection between the bed plate and pedestals.

The shaft on which the dynamometer is placed is two inches in diameter at the center and 1.96" in diameter at the ends where the pulleys rest. The shaft is rotated by two split pulleys, one situated between each pair of pedestals. These pulleys are three feet ten inches in diameter, with a nine and one half inch face. The hubs are bolted together with four $\frac{3}{4}$" bolts while the rims are held together with four, five

eighths inch bolts. The rear wheels of the automobile rest upon the pulleys in the centers of the faces, and the power transmitted to the rear wheels by the engine is expended in revolving these pulleys. The revolving of the shaft in turn actuates the dynamometer, which absorbs the power.

The tachometer used to measure the revolutions per minute of the pulleys was manufactured by the Schaeffer & Budenberg Manufacturing Co., of Brooklyn, N. Y. It is shown in Fig. 7. The driving pulley was placed on the shaft as shown at (P) in Fig. 3. Its diameter was $10\frac{1}{2}$". The tachometer was calibrated after the test by chucking the wood driving pulley in a lathe, running it at various speeds and noting the speed recorded by the tachometer as compared with the true speed obtained by an indicator. The various readings were recorded and a calibration curve plotted as shown in Figs. 8 and 9.

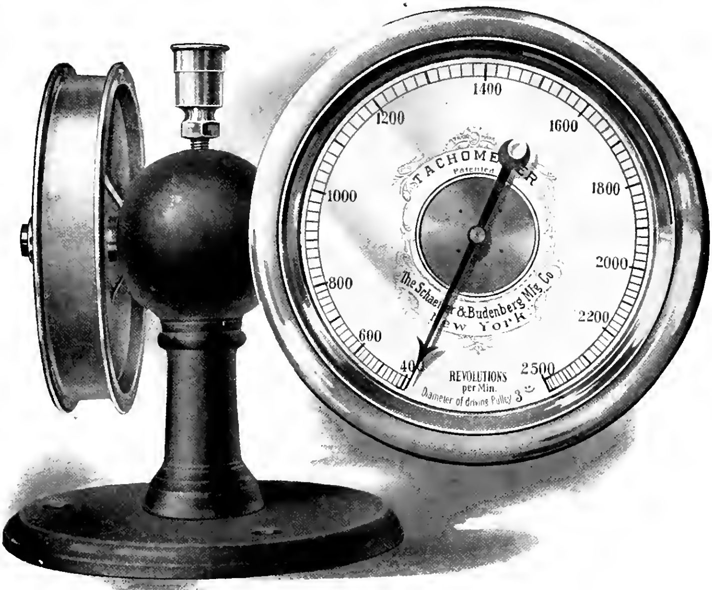
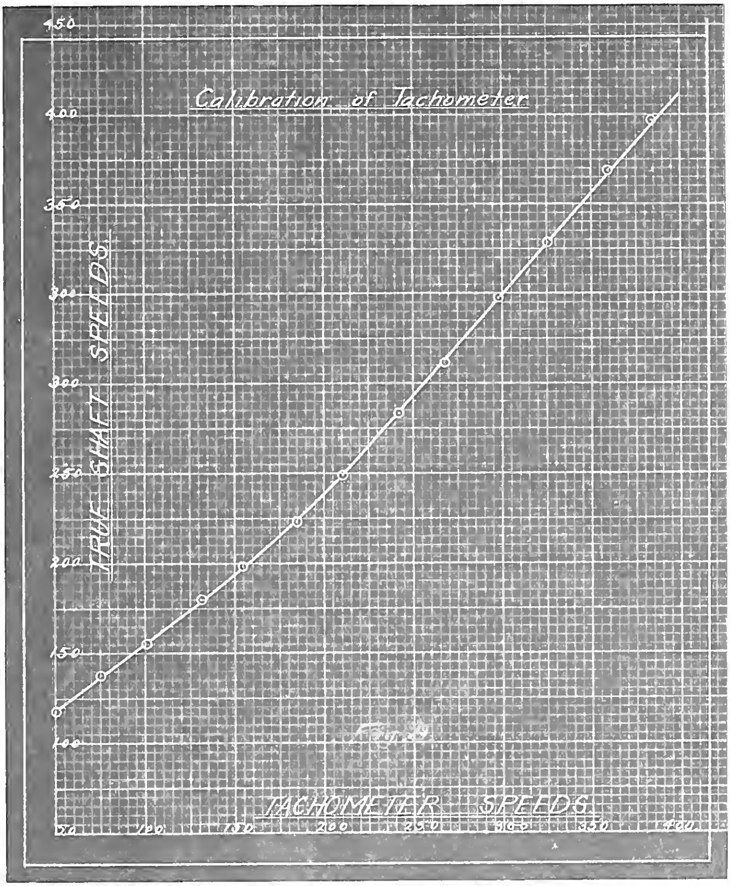

1400
1200
1600
TACHOMETER
Patented
1000
1800
2000
800
The Schaeffer & Budenberg Mfg. Co
New York
2200
600
400
REVOLUTIONS
per Min.
2500
Diameter of driving Pulley 3"

Fig. 7.

CALIBRATION OF TACHOMETER	
TRUE SHAFT SPEEDS	TACHOMETER SPEEDS.
124	50
121	57
156	85
206	167
207	170
248	210
370	320
383	325
448	388
452	390

Fig. 6.

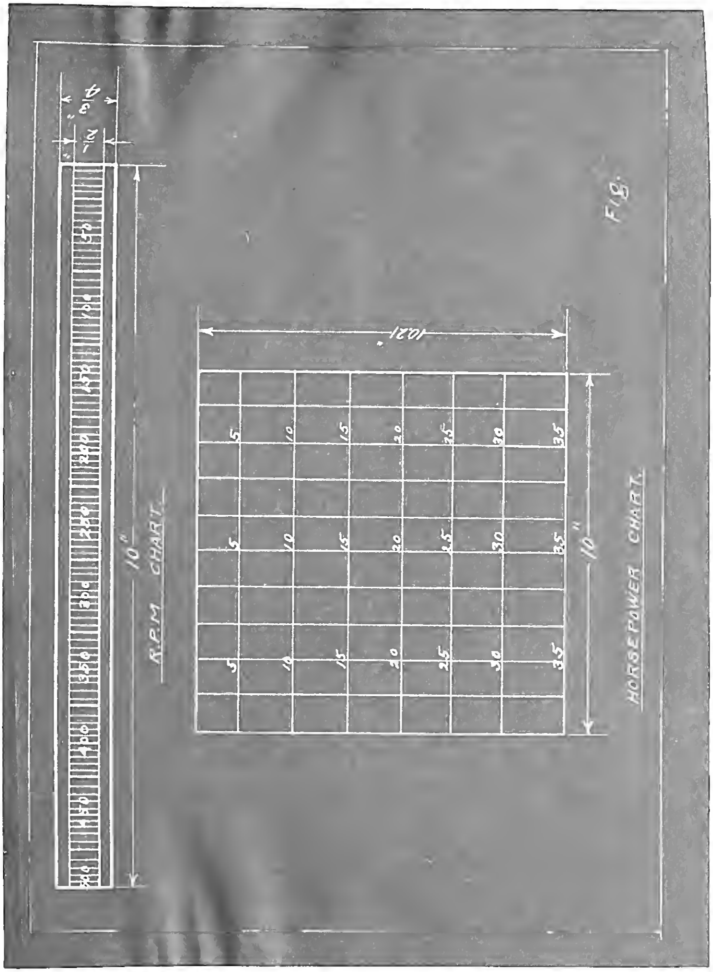

Calibration of Tachometer
TRUE SHAFT SPEEDS
TACHOMETER SPEEDS
450
400
350
250
200
150
100
50
100
150
200
250
300
350
400

The Horse Power Meter.

The horse power meter is an instrument which simultaneously records the torque and speed. The product of these two, times a constant gives the horse power delivered to the rear wheels.

The instrument consists of a drum, (A) Fig. 20 which is made of brass tubing $3\frac{1}{4}$" in outside diameter. On this drum a sheet of paper marked as shown in Fig. 10 is pasted. The reading on this drum will indicate the horse power at the speed indicated on the scale (B), just below. The drum is supported between two bearing brackets (C), on a 5/16 inch shaft by means of two flanges (X), one on each end as shown in drawing. These flanges are pressed in the tubing and secured to the shaft by means of an 6 - 32" set screw on each flange hub. The bearing brackets are securely fastened to the base plate (D), by means of 10 - 32" machine screws.

Since the horse power is a function of the torque, this drum which indicates horse power, must be connected in some way to the absorption dynamometer.


R.P.M. CHART.
HORSEPOWER CHART.
10"
FIG.

A pulley (P), Fig. 11 is connected to another pulley (A) used in place of the indicator on the Chattilion spring balance. This spring balance is fastened on some support, shown diagramatically in the above figure and connected to the lever arm (B) of the absorption dynamometer. As the load is applied to the absorption dynamometer, it is taken up and balanced by this spring balance, and the pulley which is light enough for a small cord to wind on, rotates, and in turn rotates the drum (A), of the horse power meter through (P).

The speed indicator (E) is a brass bar 3/4" X 1/8" X 15" long, held in place by three wrought iron brackets (M), which are fastened to the base plate (D). Now a connection must be made with the dynamometer shaft in order to have the speed of rotation. This was accomplished by means of the tachometer spoken of previously. A $\frac{3}{4}$" belt (H), drives the pulley (D), which is on the tachometer (F) and by means of a weight used to hold the string taut, the pointer (L) is drawn back and forth as the pulley on the tachometer rotates

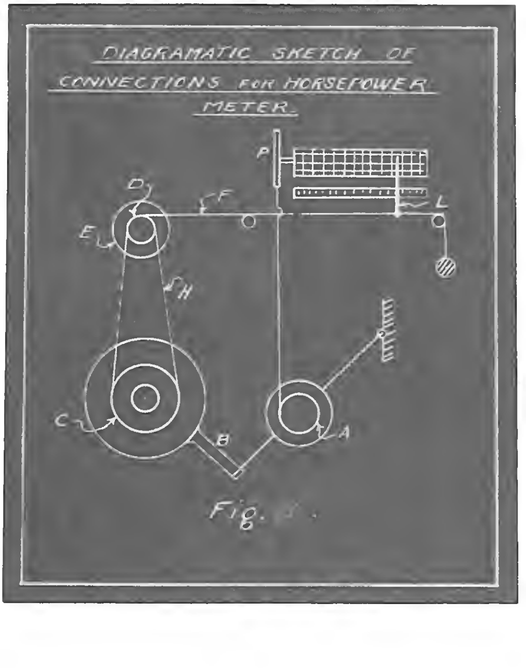

DIAGRAMATIC SKETCH OF
CONNECTIONS FOR HORSEPOWER
METER.
P
D
F
L
E
H
C
B
A

Fig.

clockwise or anticlockwise. This pulley has sufficient circumference to move the pointer (P) a maximum distance of ten inches from right to left, taking the angle that the tachometer will move, into account.

The pointer is mounted so that it simultaneously indicates the speed on the speed indicator (D) and also the position where the horse power is to be read on the drum (A). A thin wire (W), Fig. 20 is run over two pulleys (E) mounted so as to run with as little friction as possible. These pulleys are 7/8 inch in diameter and 1/8 inch thick, have a 1/8 inch steel shaft (K), 1/2 inch long. The pulley is made to rotate on two conical pointed 6 - 32 screws (S), which can be adjusted to give a very good bearing, almost frictionless. On this wire (W) is soldered the pointer (P). At the left the wire is connected to a small silk cord which winds around the pulley on the tachometer scale, and on the right a small weight is attached so as to bring the pointer back to zero when it is not operating. On this portion of the instrument rests its value, because the pulleys (E) must run as frictionless as possible as there is not much power available.

A brass front plate (T) with slots (Q) and (Z) in it, which are provided for a piece of plate glass, recessed as shown on drawing, to enable the reading of the speed and the horse power scale, is fastened to the base plate (D) by means of small machine screws. It is also fastened to the brackets (C) on each side.

Since the graduations on the drum are on the circumference, a datum line to read from, must be established. This can most easily be done by making a fine scratch on the piece of plate glass which fits in the recess (Z).

The whole instrument is to be surrounded with a removable glass case. Thus the instrument is very compact and can be bolted or screwed down in the position desired, through holes (C) provided in the base for that purpose.

Calibration of the Horse Power Meter.

After determining the limits of the apparatus by making a few trial runs on the dynamometer, the next thing to do is to calibrate and make a chart for the horse power drum and the R. P. M. scale.

The R. P. M. chart is readily constructed, as a trial piece of paper can be mounted on the scale and the tachometer can be belted to some machine which will give a range of speed from fifty to five hundred R. P. M. The scale has a maximum length of ten inches and therefore one inch of it may represent fifty R. P. M. of the tachometer. This will depend entirely on the pulley on the tachometer dial. Each inch may be divided into ten parts, each part representing five R. P. M.

Now, assuming the tachometer is carefully calibrated, and set and that it reads correctly for all speeds, it is run say at fifty R. P. M. and then the position of the pointer on the R. P. M. scale of the horse power meter is marked. The speed can be increased in fifty R. P. M. increments and for each different speed the position of the pointer is marked on the scale.

In order to get points in between, it would be best to take speeds say from fifty to one hundred fifty R. P. M. and see if five R. P. M. increments are proportional. To eliminate all errors the same scheme would be used on higher speeds.

With these various points obtained, a chart can be made, and firmly fixed on the brass bar for that purpose.

Since the horse power depends on torque, the most convenient method of calibration is by means of the dynamometer itself. A series of runs at different speeds and different loads for each speed must be taken. The Chattilion scale will carry a load of 1000 pounds, so 100 pound increments of load may be best taken until a maximum is obtained, and the corresponding speed is taken for each increment of torque. A blank piece of paper is fixed on the drum and for each change in torque the rotated position of the drum is marked in reference to a datum line, drawn at a zero position on the drum. Then, knowing the speed at which this torque was developed and by means of the formula,

$$H.P = \frac{2\pi R\ G\ N}{33,000}, \quad \text{where}$$

R = Radius of brake arm in feet.

G = Load on scale

N = Number of revolutions per minute,

the horse power for these various points can be calculated. They can then be plotted and the horse power of the points in between interpolated and plotted.

Having obtained a calibration chart, the final one can be made from it and fixed on the drum and set. From time to time checking must be done to eliminate errors due to wear and slippage in order to obtain consistant results.

Method of Measuring Various Loads.

Due to the fact that the construction of the horse power meter was not finished, it was necessary to use different methods of measuring the various loads from the ones intended. The traction effort was measured as follows: A one inch bolt was put through the fourteen inch wall of the building and fastened by means of a nut. This was placed at the same height as the center line of the four inch channel beam which holds the two longitudinal beams of the framework of the automobile in place, and perpendicular to the center line of the automobile as shown in Fig. 3. A one half inch steel cable was connected to this bolt, the other end being connected to a Chattilion spring dial scale, This spring was in turn connected to the chassis through a one half inch piece of soft steel, threaded at each end and held in place by means of lock nuts. These nuts made it possible to adjust for the increase in forward motion of the automobile due to elongation of the spring in the scale. The traction effort was read directly on the scale.

The load on the dynamometer was measured on a small platform scale. The load was varied by means of water pressure through the dynamometer. The torque was easily obtained by multiplying by the brake arm.

In order to know the slippage between the tires and the pulleys, a tachometer was placed so as to measure the revolutions per minute of the pulleys. The revolutions of the tires were taken per unit time and the corresponding number of revolutions per minute of the pulleys calculated. The difference between the two results gave the slippage. This assumes that the tires are of constant diameter, which may or may not be true.

Assembly of Apparatus.

A pit 7'-2½" wide, 5' - 3" long and 4' - 4" deep was made for the dynamometer. The sides of the pit were of concrete, while the bottom was filled in with loose stones to the required level to await the permanent placement in concrete of the dynamometer. Running back from the pit and 2' - 7¼" from each side was a channel 24" wide and 14" deep, lined on sides and bottom with concrete.

When the dynamometer had been completed, it was assembled in the machine shop to see that the shaft was running smoothly, and that there was no grinding of the parts in the dynamometer itself. After the test it was placed in the elevator and lowered to the ground level. It was then placed on a cart and pulled over to the laboratory. By block and tackle it was lowered into the pit. The correct height was established and the bed plate made level by means of wedges. (See Fig 3)

A thin concrete was allowed to flow under the bed plate and fill up the hollow portion of it. After setting two days, the remainder of the pit was

cleaned of sand and loose stones which had been used as a wall around the bed plate so as not to allow the concrete to flow anywhere except under the bed plate. A 1 to 3 to 5 mixture of concrete was made and the remainder of the space filled with it up to a level of the top of the bed plate. Thus it was held in place by a solid concrete foundation and a concrete slab of 5 inches thickness. The whole was then allowed to set for three days.

A covering for the pit was then made of hard maple boards 2" x 5" bolted to four 2" L beams. A trap door 1' - 6" x 2' - 8" was made to admit of measurements and load adjustments.

Part 3.

Data obtained from a series of instantaneous readings taken with wide open throttle.

Introduction.

After all our apparatus was in readiness the automobile was backed on the pulleys and then made ready for testing. After running the engine at high speed, it was found to be impossible to keep the engine cool, and keep the circulating water from boiling after three minutes of running. This necessitated taking instantaneous readings. When the proper load and speed had been obtained and the reading taken, it was necessary to stop the engine.

To let the engine cool to a point where it was possible to drain the radiator and put in city main water took from thirty to forty minutes. Hence only two or three readings could be obtained in an afternoon.

Another difficulty we met with, was the excessive heating of the rear tires, to a point where it became dangerous for fear of explosion.

Because of these difficulties, it was decided to make six or seven instantaneous runs, with wide open throttle, at different loads. These runs were to constitute the testing. Various curves are found following the data, in Figs. 15, 16, and 17.

Test of the Chassis.

The chassis was the 1911 Model Halladay described in the first part of the thesis.

The object of this test was to obtain a characteristic power curve from the power transmitted at the rear wheels of the chassis, without making any attempt to determine the fuel consumption or the efficiency of transmission.

The chassis was backed on the two pulleys so that the rear wheels were on the center of the pulleys respectively. It was then blocked and the cable connection from the wall to the frame made.

The horse power is figured as follows:

$$\text{H. P} = \frac{2\pi R \quad n \quad P}{12 \times 33{,}000}$$

$$= \frac{2\pi\, 18.925 \times 244.26 \times 228}{12 \times 33{,}000}$$

$$= 17.5, \quad \text{where}$$

R = Length of brake arm in inches

P = scale reading (net pounds)

n = R. P. M.

In order to get the tractive effort, the tendency of the car to move forward must be resisted. To do this a spring balance was put between the cable and the chassis frame. This measured directly the tractive effort in pounds. The traction horse power is calculated as follows:

$$H.\ P. = \frac{2\pi R\ n\ P}{12 \times 33,000}$$

$$= \frac{2\pi 17.562 \times 198 \times 250}{12 \times 33000}$$

$$= 13.78,\ \text{where}$$

$P =$ scale reading (pounds)

$n =$ R. P. M. of rear wheels (mean)

$R =$ mean radius of rear wheels.

The speed of each rear wheel was taken with a speed indicator simultaneously in order to take into account any differential action.

In conducting the test, one man was stationed at the wheel controlling the spark and throttle. The entire run was made on high gear and magneto ignition. No trouble in starting the engine was experi-

enced. With the engine going smoothly the clutch was thrown out and the engine was thrown in high gear and run throughout on wide open throttle. Loads applied by means of the absorption dynamometer were of such amount as to obtain different speeds, ranging from 85 to 225 R. P. M. as indicated by the tachometer. These loads were held constant by a man operating the inlet and outlet water valves connected to the dynamometer. When the load and speed were constant, the readings of the traction pull and the speeds of the rear wheels were taken. The data collected is found in Figures 12, 13 and 14 on pages

On examining the above curves it is seen that they possess the characteristic of a gasoline engine power curve. As the speed increases, there is a gain in torque up to a certain point where it reaches a maximum and with any further increase in speed, a decrease in torque results. The traction curves show a similar state, with increase in torque there is an increase in tractive effort up to a certain point.

The slip obtained can not be taken as authen-

tic data, because the determination of the speed at the rear wheels could not be done accurately due to a variation in the load and in the speed of the machine.

NO. 1. TEST WITH WIDE OPEN THROTTLE

LOAD	NET LOAD.	TACHOMETER R.P.M	CORRECTED	TORQUE FT. LBS.	ABS. H.P.	SLIP. R.P.M.
175	169.26	85	145	268	7.42	6.
190	184.26	110	163	291	9.05	2
200	194.26	155	198	307	11.6	1.
220	214.26	175	215	339	13.88	3
250	244.26	200	238	386	17.5	4
200	194.26	225	265	307	15.5	-2

Fig. 12.

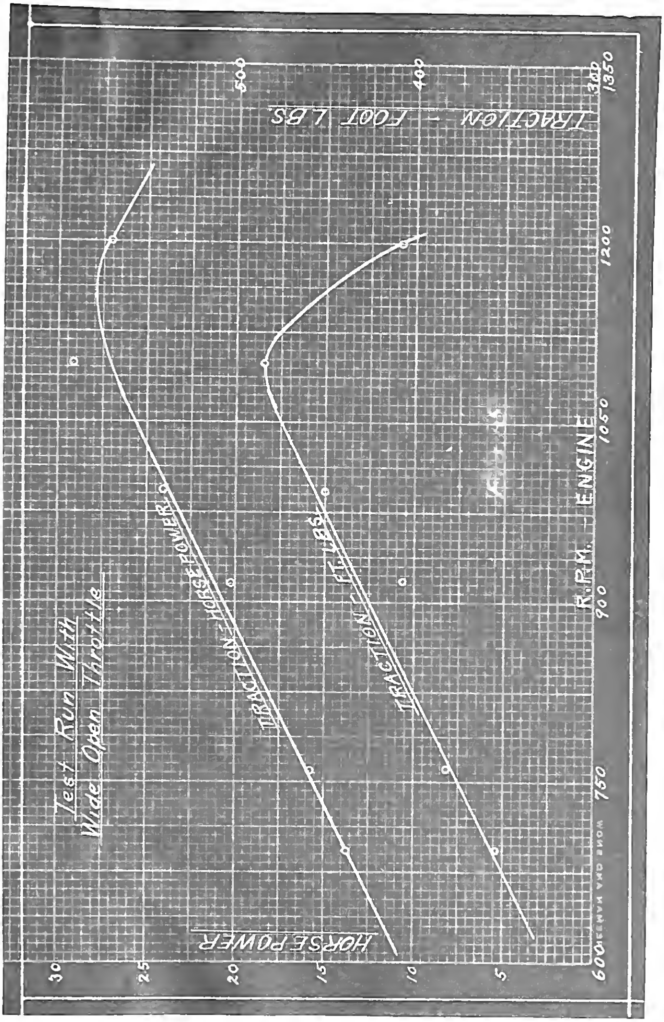
NO. 2. TEST WITH WIDE OPEN THROTTLE. CONT.

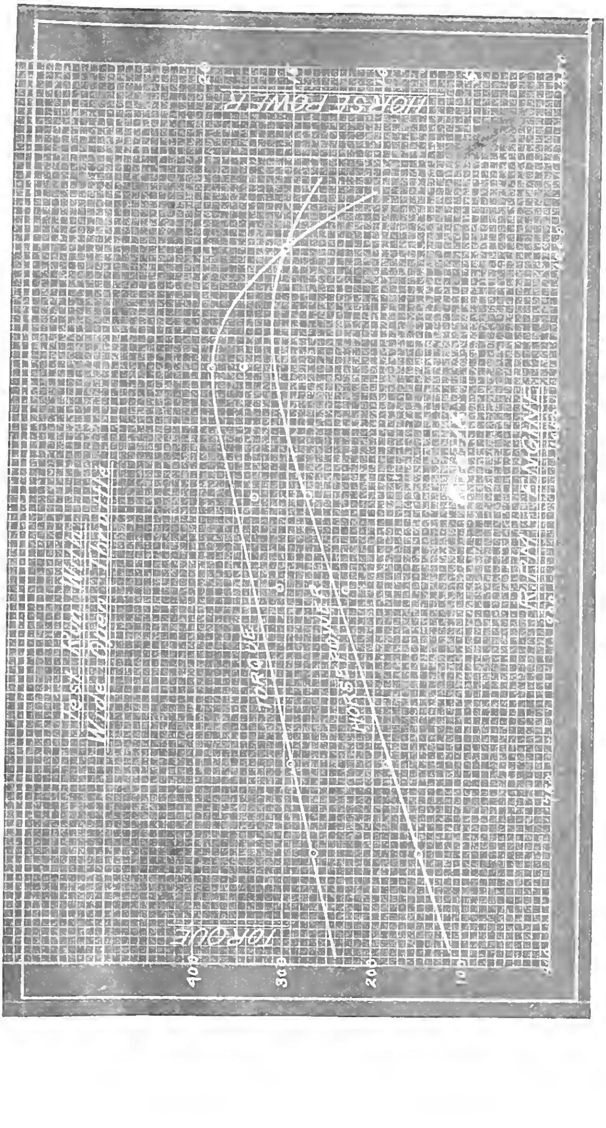
TRACTION PULL	TRACTION FT. LBS.	R.P.M. REAR WHEELS L.	R.P.M. REAR WHEELS R.	RADIUS REAR WHEELS L	RADIUS REAR WHEELS R.	MEAN.
250	354	196	200	17 11/16"	17 3/8"	17.532
262	382	214	220	"	17 5/16"	17.495
280	407	264	260	"	"	"
305	450	290	278	"	17 11/16	17.688
330	485	315	315	"	"	"
280	407	345	340	"	"	"

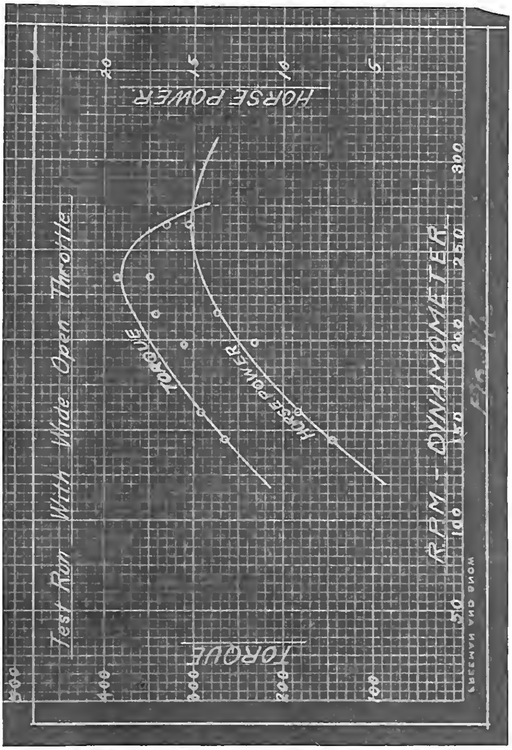
Fig 13

NO. 3. TEST WITH WIDE OPEN THROTTLE. CONT.

MEAN R.P.M REARS WHEELS	ENGINE SPEED.	TRACTION H.P.			
198	694	13.78			
217	760	15.65			
262	917	20.3			
284	994	24.3			
315	1100	29.2		Fig 43	
342.5	1200	27.0			


Test Run With
Wide Open Throttle
TRACTION - HORSE POWER
TRACTION - FT. LBS.
HORSE POWER
TRACTION - FOOT LBS.
R.P.M. - ENGINE
600
750
900
1050
1200
1350
30
25
20
15
10
5
500
400
300


HORSE POWER
Test Run With
Wide Open Throttle
TORQUE
HORSEPOWER
TORQUE
400
300
200
100


Test Run With Wide Open Throttle
HORSE POWER
TORQUE
R.P.M. - DYNAMOMETER
20
15
10
5
300
250
200
150
100
50
500
400
300
200
100

APPENDIX.

Bibliography.

Motor Testing Plants; J. Ed. Schipper,

Automobile, 28:640 Mar. 13, '13.

Modern Chassis Testing; P. P. Dean,

Horseless Age, 31:669 April 9, '13.

Road Tests for Automobiles; W. D. Ennis,

Horseless Age, 31:634 April 2, '13.

The Measurement of Horse Power; W. Morgan and E. B. Wood,

S. A. E. Bulletin July, 1913.

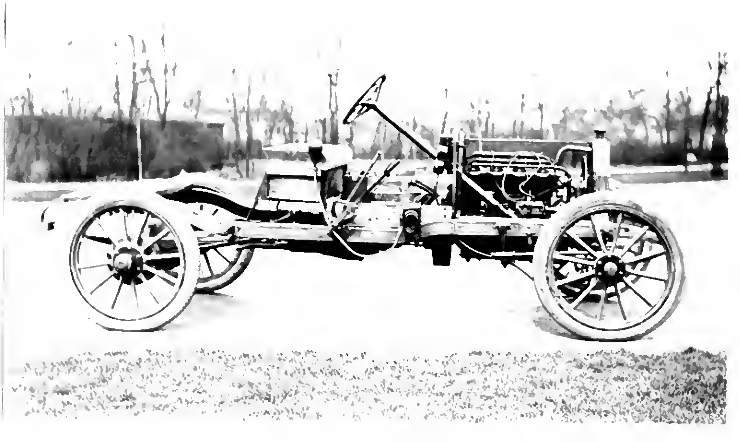
Chassis Testing Apparatus; P. P. Dean,

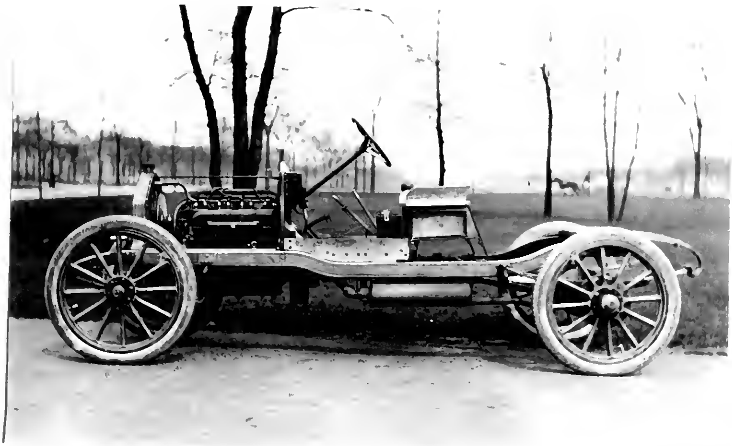
S. A. E. Bulletin Aug., 1913.

The Automobile as a Product of Research and Investigation; R. C. Carpenter,

Sibley Journal of Engineering, 27:341 June, 1913.


27939





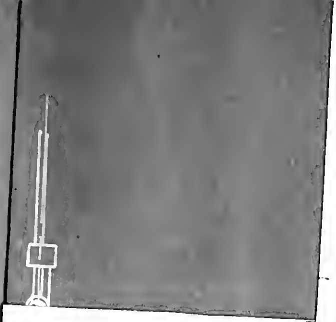
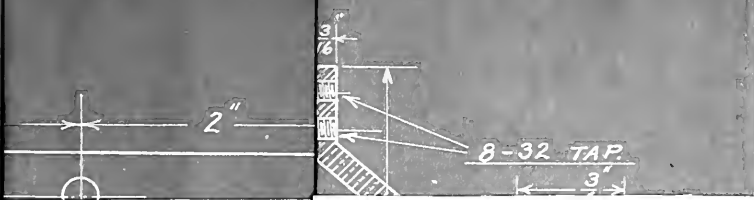


FIG. 3.

FIG. 20.



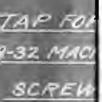


Fig. 21.